Occupational and Environmental Exposures of Skin to Chemicals 2005 (OEESC 2005)

A White Paper for discussion in Workshop 4: Process Based Qualitative Risk Assessment

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BACKGROUND

Significant resources have been invested over the last 30 years to develop methodologies to reduce inhalation exposure to substances hazardous to health. This investment has helped to reduce the incidence and prevalence of work-related respiratory disease and highlight the relative significance of work related skin disease.

During the last decade therefore, regulatory and scientific research agencies within the European Union (EU) and North America have recognised and agreed to the aim to significantly reduce dermal exposure to hazardous substances and wet work, hereafter referred to as 'chemical agents'. A number of approaches have been initiated to meet this aim and they include the development and application of risk assessment tools and dermal exposure measurement techniques for use in the qualitative assessment of risk of dermal exposure to chemical agents.

EXPOSURE RISK

The interaction of chemical agents with the skin can result in one or more of the following three outcomes:

- absorption of the chemical agent through the skin and subsequent contribution to systemic effect;
- induction of localised effects on the skin such as irritation, burns, or depigmentation;
- allergic reaction of the skin due to immune system responses.

In each case, the skin must come into contact with and/or be exposed to the chemical agent.

Qualitative assessment of an individual's inhalation exposure to chemical agents can be carried out fairly easily by using colour change indicators, photo ionisation detectors or similar real time monitors placed in close proximity to the individual's 'breathing zone' as defined by regulatory and standards setting agencies.

Qualitative (and for that matter quantitative) assessment of an individual's dermal exposure to chemical agents however is complicated by several variables. These include:

- the total surface area of an individual's skin (obviously variable but typically about $2m^2$);
- the three ways in which dermal exposure can occur (immersion, deposition from air and surface contact);
- the actual area of the skin directly exposed to chemical agents by any of the three routes at any one time;
- secondary/tertiary exposures resulting from the initial exposure (e.g. from clothing to skin or from hand to mouth/eyes/nose etc.);
- the pre-existing condition of an individual's skin (e.g. levels of hydration, cuts and abrasions, etc.);
- the resultant effect of skin exposure to complex chemical substances;
- differences in how individuals may carry out similar tasks and wear and care for their personal protective equipment (PPE).

The situation is further complicated by the current approaches for classifying dermal exposure as potential and actual exposures even though they are inter-related to a significant extent. For example:

- extensive data is available to show that hands are the most frequently contaminated part of the body whilst the extent of exposure to other parts of the body is dependent on the work process, clothing worn, type of PPE chosen and how effectively it is worn.
- procedures and practices used for removing contaminated clothing and PPE strongly influence dermal exposure risk;

The above are well illustrated by the conceptual model of dermal exposure proposed by Schneider et al.

QUALITATIVE EXPOSURE ASSESSMENT APPROACHES

1) Regulatory Procedures

Inhalation exposure risk to many chemical agents can be judged against nationally (and in some cases internationally) agreed inhalation exposure limits. There are as yet no realistic proposals to develop exposure limits for dermal exposure risk assessment. The likelihood therefore of the future availability of any limits for even a small number of substances is not, at present, foreseen.

Additionally, progress towards establishing experimentally derived NOAELs (No Observable Adverse Effect Limits) for dermal exposure will also be very slow.

Currently, national regulatory agencies assign a 'skin notation' (Sk) to substances they consider can contribute substantially to total body burden by uptake via unbroken skin and cause systemic health effects. An 'International Perspective on the Criteria for Skin Notation' was presented at OEESC 2002 identifying significant differences of opinion in the way chemicals should be selected for this purpose however. There are in total only about 160

substances currently assigned (but not all agreed internationally) Sk notations and this may be considered as the tip of the 'dermal' iceberg. Sk notations can be used in hazard and exposure risk control assessments without the need of workplace exposure measurements.

Various risk phrases (R-phrases) have been developed within the EU to indicate health hazards associated with chemical agents and there are several R-phrases associated specifically with dermal exposure hazards. However, the approaches taken to assign R-phrases have attracted criticism.

Furthermore, although R-phrases are widely used for exposure assessment and risk control decisions, occupational dermal exposure to chemical agents is still commonplace. Qualitative exposure assessment tools are useful for demonstrating actual dermal exposure and inadequacies of risk control methods.

2) Risk Assessment Models

A number of qualitative dermal exposure assessment models, based on ranking various determinants of dermal exposure, have already been developed and some are in widespread use. Examples include EASE, the RISKOFDERM Toolkit and DREAM.

The models are accessible in paper and/or electronic format. They have yet to undergo an internationally agreed programme of critical evaluation however and are known to vary in the degree of scientific accuracy offerred.

3) Surrogate Skin or Interception Methods

These methods involve individuals wearing chemical collection pads. Two general approaches have been used: patch samplers covering small skin surface areas and garment samplers covering whole anatomical regions, e.g. gloves, coveralls. After a specific task has been completed, the pad is removed and analysed for chemical content to estimate the potential/actual exposure.

The practical usefulness of these methods rests upon careful consideration of the retention capacity of the sampling medium; different sampling media can be used to measure either the retained exposure on the skin or the total loading of the skin/clothing irrespective of retention. Several reviews of these methods have been published and they are considered to be simple and useful though scientifically limited. The extraction solvents used however can be very toxic and contribute to VOC emissions and water/soil contamination.

4) Removal Techniques

Removal techniques include skin washing and wiping. These measure only what can be removed from the skin at the time of sampling rather than the actual skin loading. Water-alcohol wash solutions are generally used to assess hand exposure, while wiping techniques can be applied to work

surfaces. Sampling of work surfaces can be useful as it provides an estimate of dermal exposure potential and can be an effective way of showing if a cleaning or segregation policy is working.

5) Biological Monitoring

Biological monitoring (BM) can be used to indicate how much of a chemical has entered the body. It is especially useful when:

- there is the likelihood of significant absorption through the skin;
- control of exposure relies wholly or partly on PPE (BM will identify chemical exposures by the three routes of inhalation, ingestion and dermal);
- there is a reasonably well defined relationship between biological monitoring and systemic effect; or,
- systemic toxicity is related to long term tissue accumulation of a chemical and not airborne measurements taken at a particular time.

BM involves the measuring of the chemical agent (or break-down products) in a sample of breath, urine or blood and comparing that measurement against a reference value called a biological guidance value (BGV). BGVs have been set nationally in the UK for a small number of substances.

Regular BM can also be useful as it provides an indicator of exposure trends and can be an effective way of showing if a cleaning or segregation policy is working.

6) Visualisation

Measurement of deposition of fluorescent materials when viewed under ultra-violet light can be used to assess skin exposure qualitatively or quantitatively.

It is a very useful technique for demonstration and training purposes but to quantify exposure is complicated and requires expert handling and interpretation. The method is limited to where it is practicable to add fluorescent dyes to the process chemicals or where the agent of interest naturally fluoresces

Colorimetric reagents that react with the chemical agent of interest to allow detection of the chemical on surfaces are also an option. Reagents for some chemicals are presently commercially available and additional ones could be developed.

WORKSHOP DISCUSSION PLAN

For ease of reference, the workshop discussion plan is shown at Fig 1 in diagrammatic form. The workshop panelists will each present a case study pertinent to process based qualitative dermal exposure risk assessment to chemical agents as follows:

1. Timber treatment by Nick Warren;
2. Cleaning printing machines by Martin Roff;
3. Handling MbOCa in plastics production by Bob Rajan.

Time will be allowed following each case study for discussion amongst the workshop participants on the role of qualitative assessment methods for each of the three demal exposure pathways as per the following three summary statements (a) to (c).

A further period of time will then be allowed for the workshop to conclude by considering in overall terms for all three case studies the usefulness of qualitative assessment and the difficulties in obtaining a representative picture as per the following two summary statements (d) and (e).

Summary statement (a) - immersion

Qualitative (quantitative) assessment for processes/tasks involving immersion is of little or no use. Direct action to eliminate/control immersion is the way forward. Qualitative dermal exposure assessment methods may however be used for demonstrating the effects of secondary exposures resulting from immersion.

Summary statement (b) - deposition

If deposition is the major dermal exposure route then air level monitoring and inhalation exposure control can be the best way forward. If airborne levels of contaminant are controlled to within the relevant inhalation exposure limit then as a generality, dermal exposure by deposition will also be under control. This is because inhalation exposures within the inhalation exposure limit usually indicate the total body burden (resultant from exposure by all routes) to be within acceptable levels. There may be exceptions to this assumption however for substances (e.g. certain glycol ethers) readily absorbed by the skin.

Summary statement (c) – surface contact

Surface contamination – in many cases, this route of exposure (worksurfaces, clothing) can be a significant problem and will require surface contamination monitoring to establish that a problem exists. Also, regular surface monitoring can be an effective way of demonstrating the extent of the effectiveness of control approaches and showing that a cleaning or segregation policy is working.

Summary statement (d) – usefulness/applicability/strengths or advantages

Qualitative measurement of dermal exposure can be useful in judging the effectiveness of control measures, such as any PPE that may be worn. Routine exposure measurements can also be useful in identifying any trends in workplace exposure and ill heath reduction.

Summary statement (e) – difficulties/obstacles/limitations

Obtaining a representative picture of the extent of dermal exposure however can be difficult. The choice of method will be driven by the user preferences except for those substances with specified regulatory requirements.

DELIVERABLE

The panelists will produce a follow up green paper reflecting the views of the workshop for further consideration.

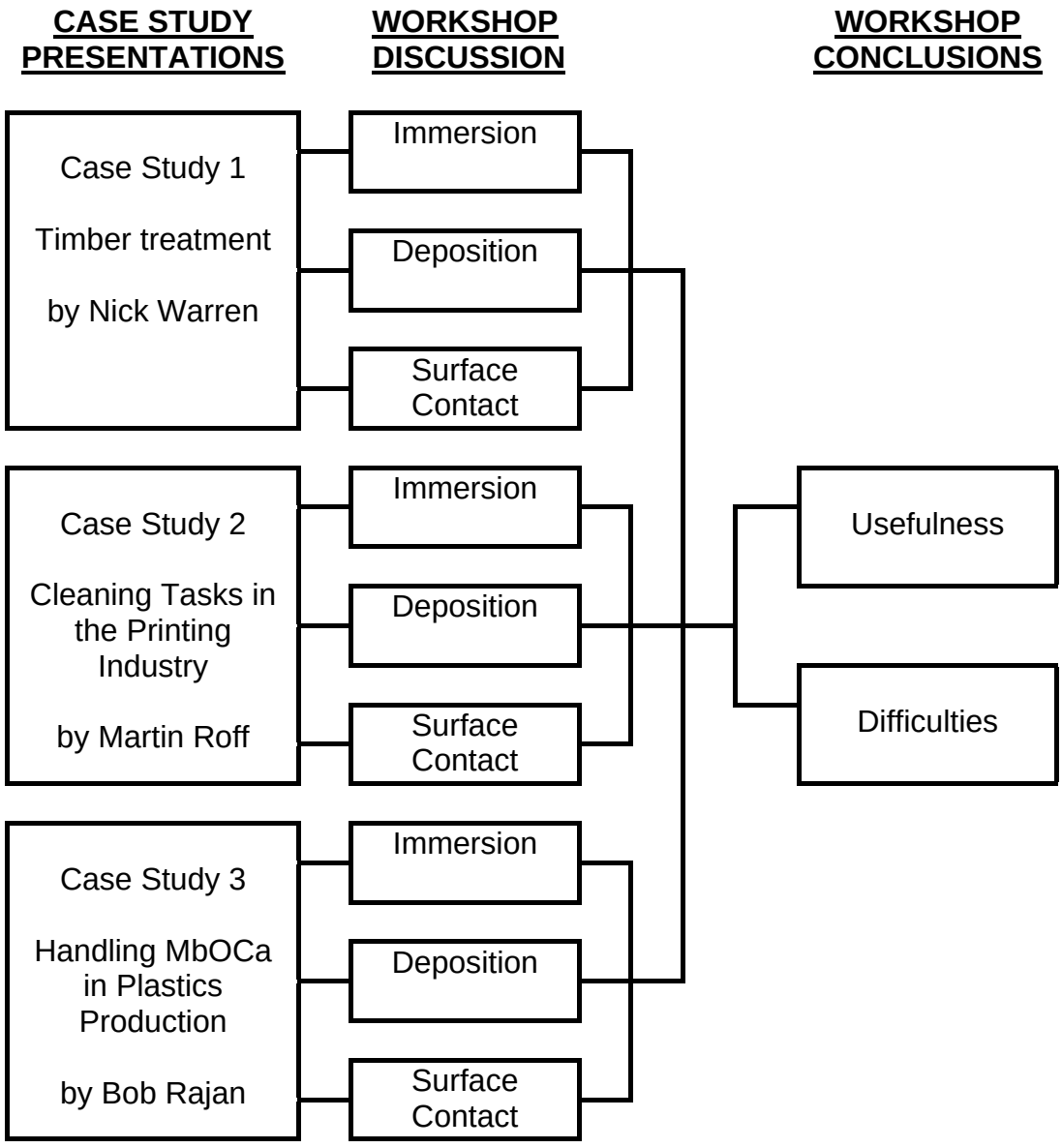

FIG 1: WORKSHOP DISCUSSION PLAN SCHEMATIC

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